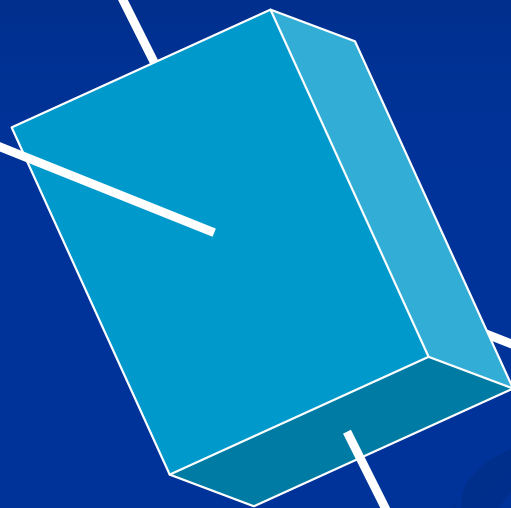


The Australis-OSCAR-V Mission



Jan A. King, W3GEY/ VK4GEY
AMSAT-NA
23 July 2011
Melbourne, Australia

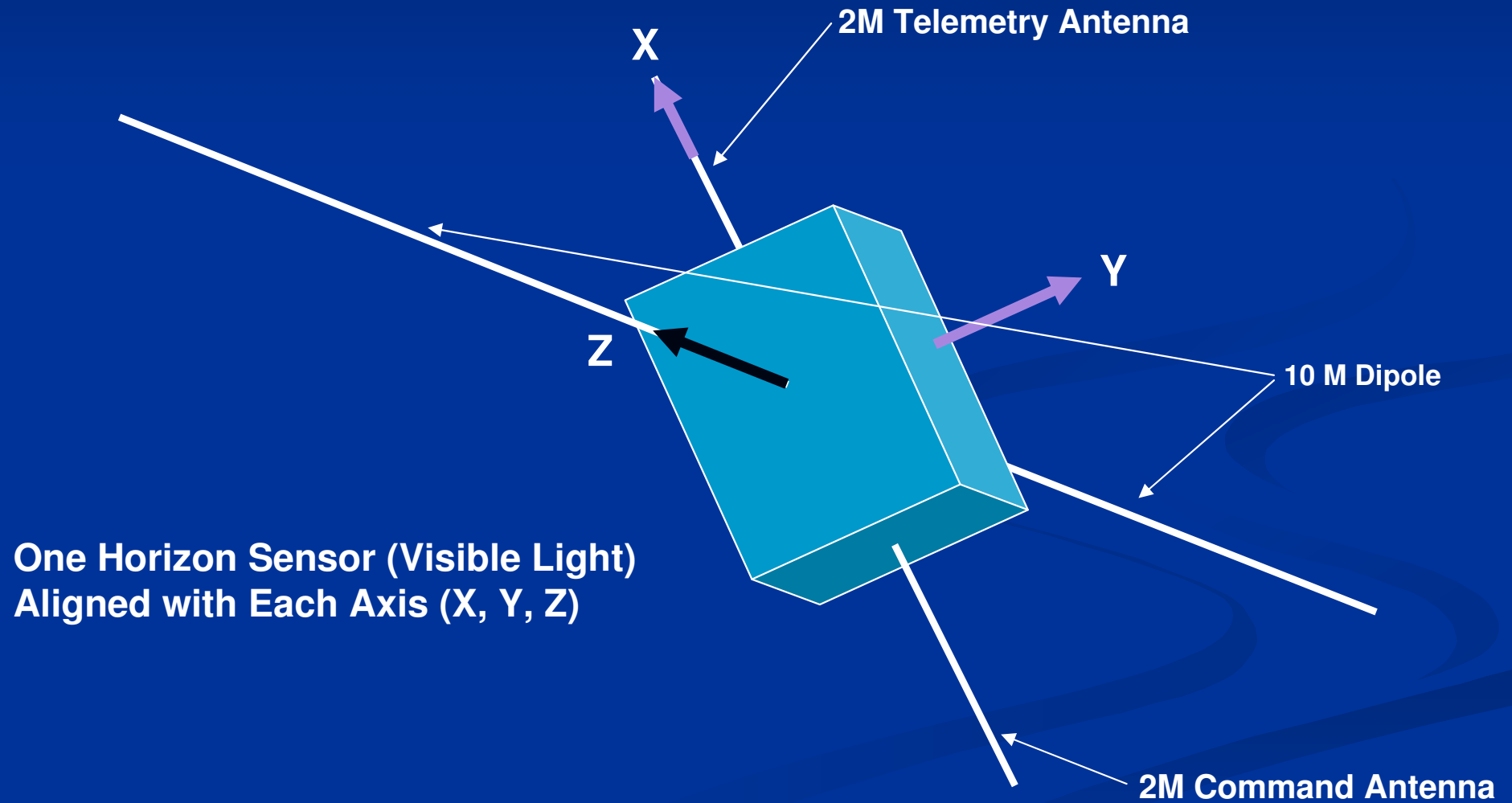
The Firsts

- First Australian built satellite. (WRESat was built after AO5 but flown before.)
- First non-US amateur satellite. First non-US satellite launched by NASA.
- First HF transmitter flown on an amateur satellite.
- First MUXed telemetry system flown and proven on an amateur satellite.
- First command system flown and proven on an amateur satellite.
- First "PMASS" passive magnetic stabilization and orientation system to stabilize and orient a satellite. There have been about 40 subsequent systems flown.
- First Use of "Standard Orbits" method for predicting passes and for tracking. This was later adopted and improved by NASA for use by US Antarctic expeditions.
- First time that satellite predictions (in this case equator crossings) had been transmitted directly from a computer to users via radio without human intervention.
- In addition, AO5 trained two groups, the Australians and the US AMSAT group whose achievements have been subsequently noteworthy.

Launch Date and Orbit

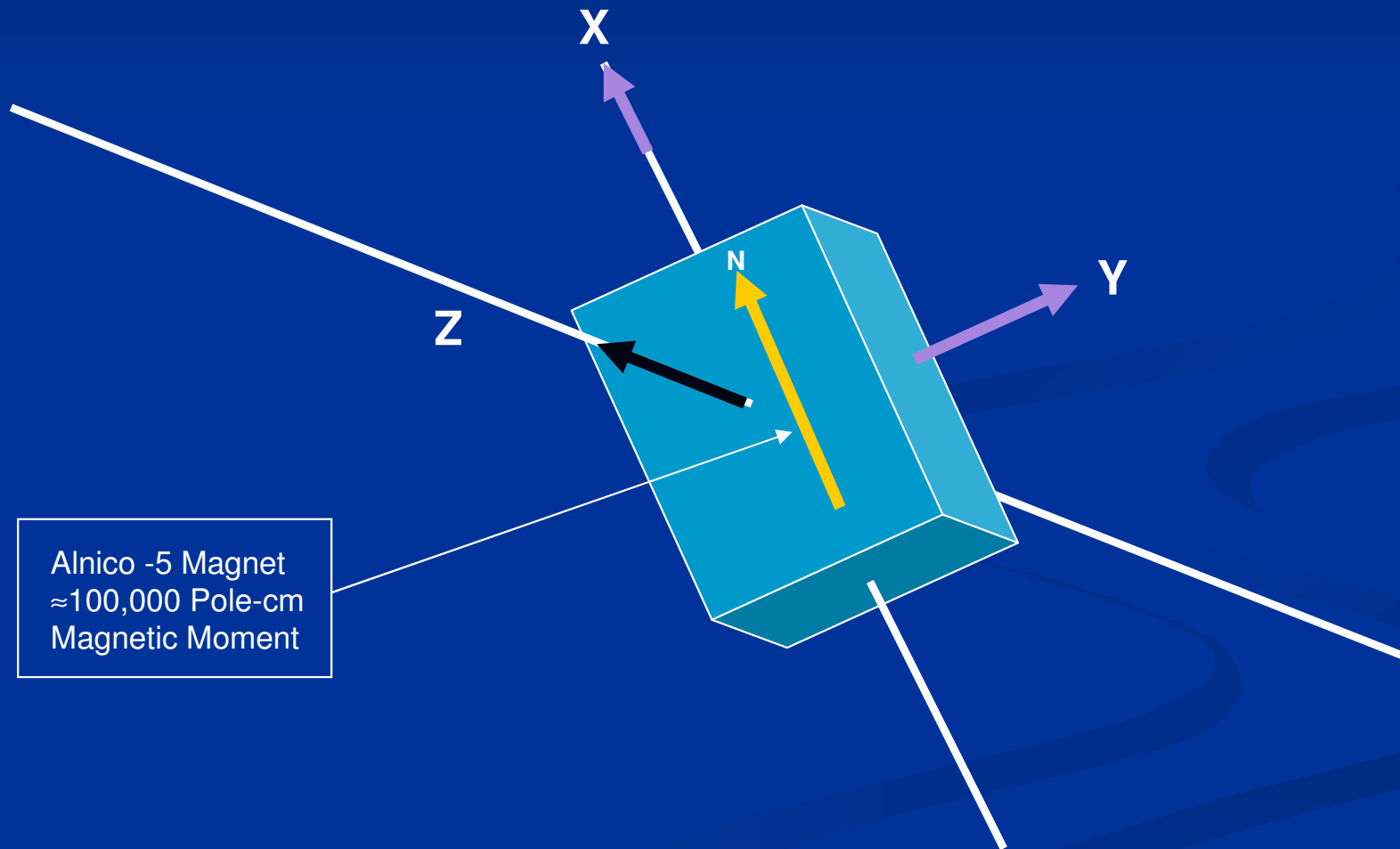
- Launch: 23 January 1970
- Orbit: 1477 km X 1434 km X 102.04°
- Orbit Mean Motion/Period: 12.51 orb./day
115.00 min/orb.
- Size & Mass: 30.4 x 43.1 x 15.2 cm;
17.700 Kg.

AO-5 Coordinate System



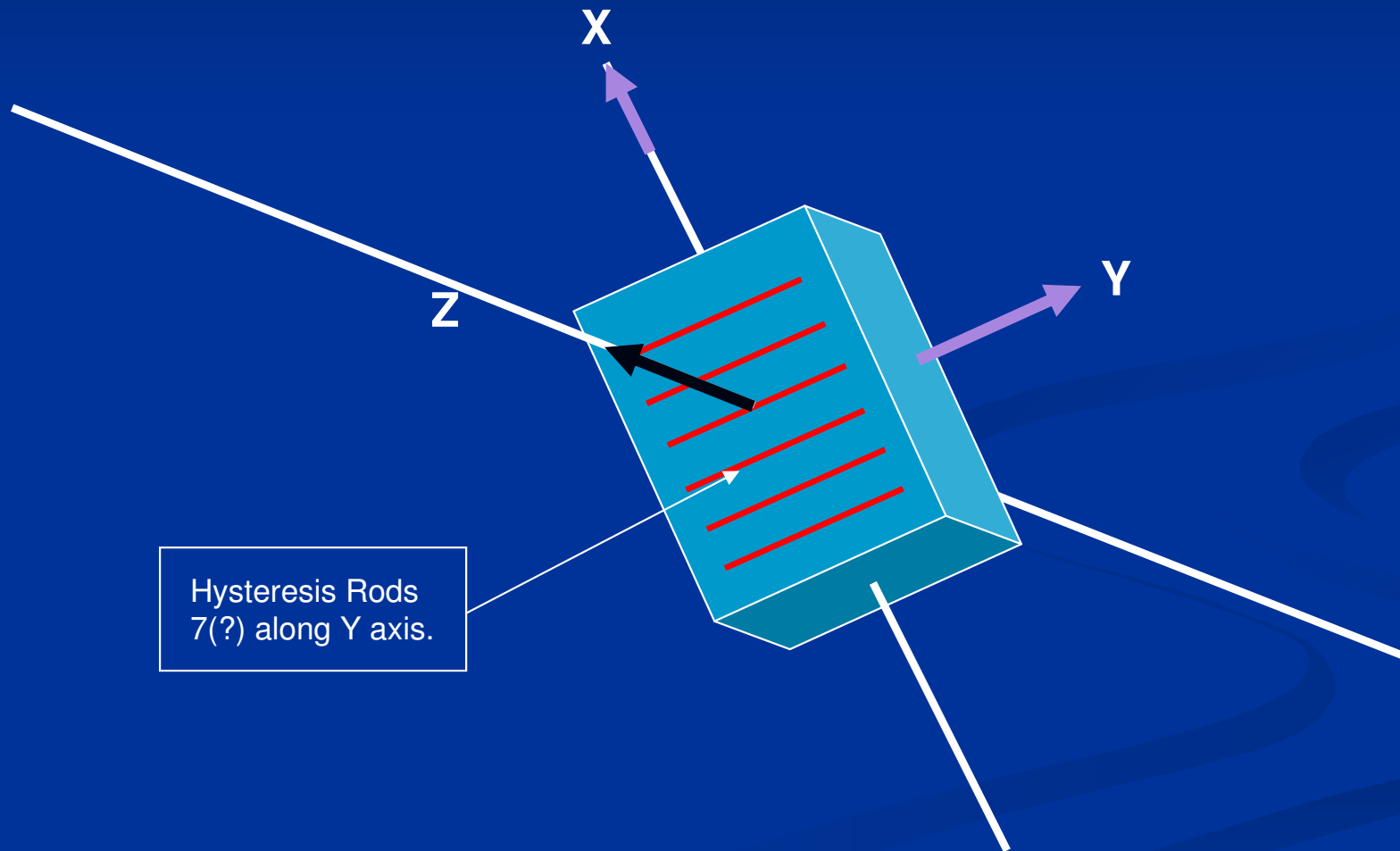
PMASS – Passive Magnetic Stabilization System

- Permanent Magnet Alignment -



PMASS – Passive Magnetic Stabilization System

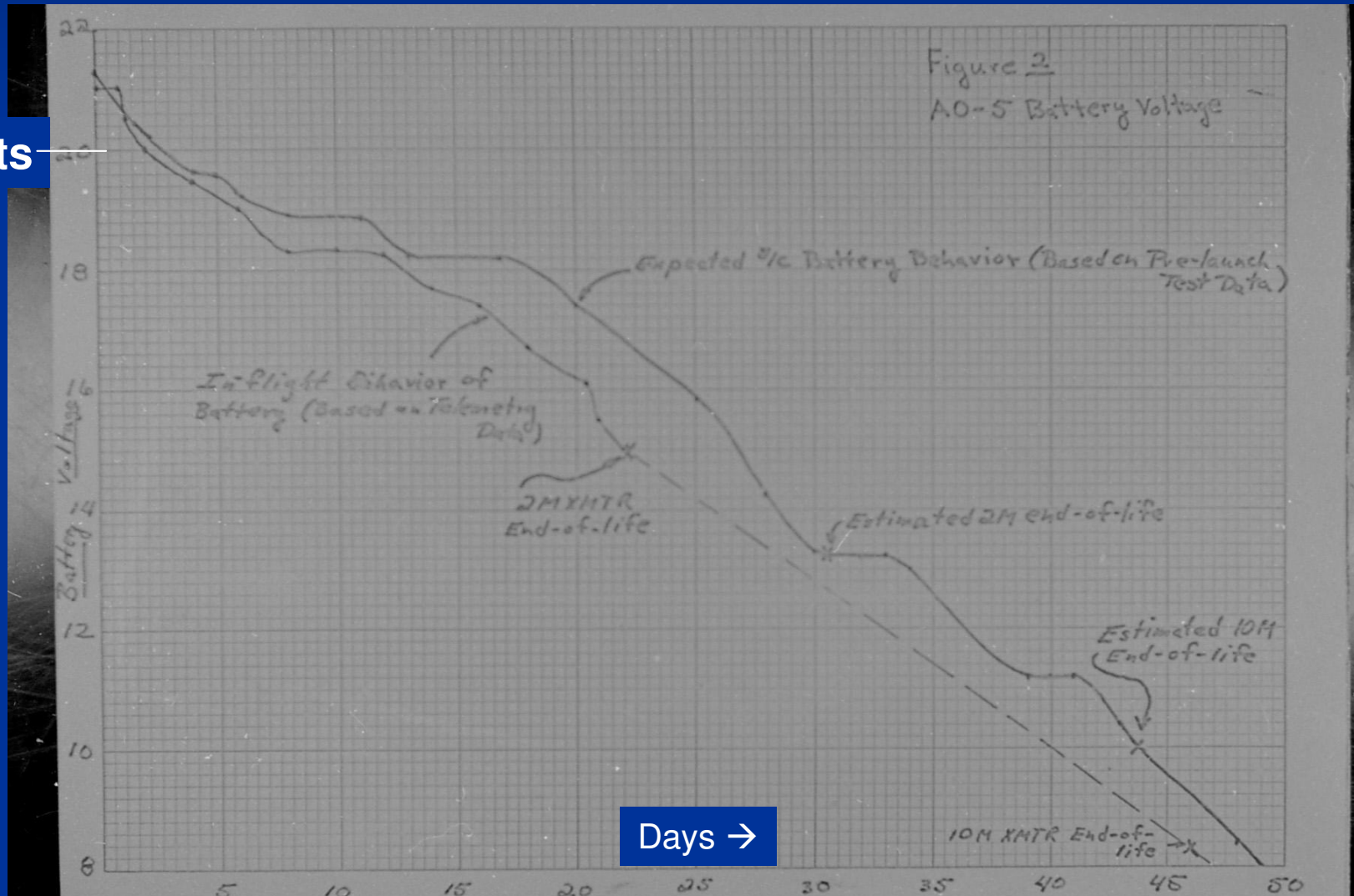
- Hysteresis Rod Alignment



Power Subsystem

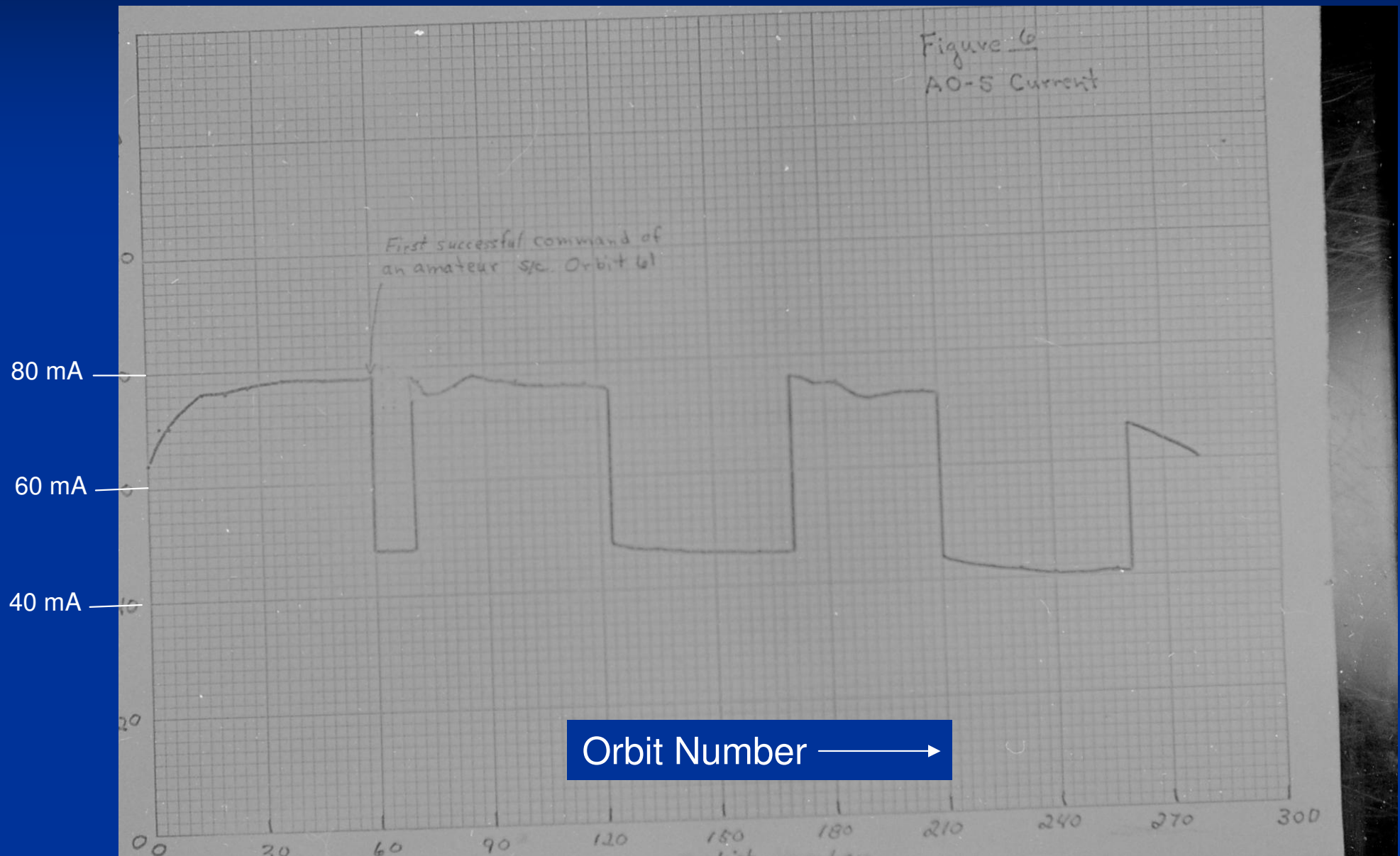
- Alkaline Primary Battery – No Solar Cells
- Command System to Shut Off 10 Meter Beacon

20 Volts



Power Subsystem (2)

- Current Consumption -



PMASS Expected Attitude Behaviour

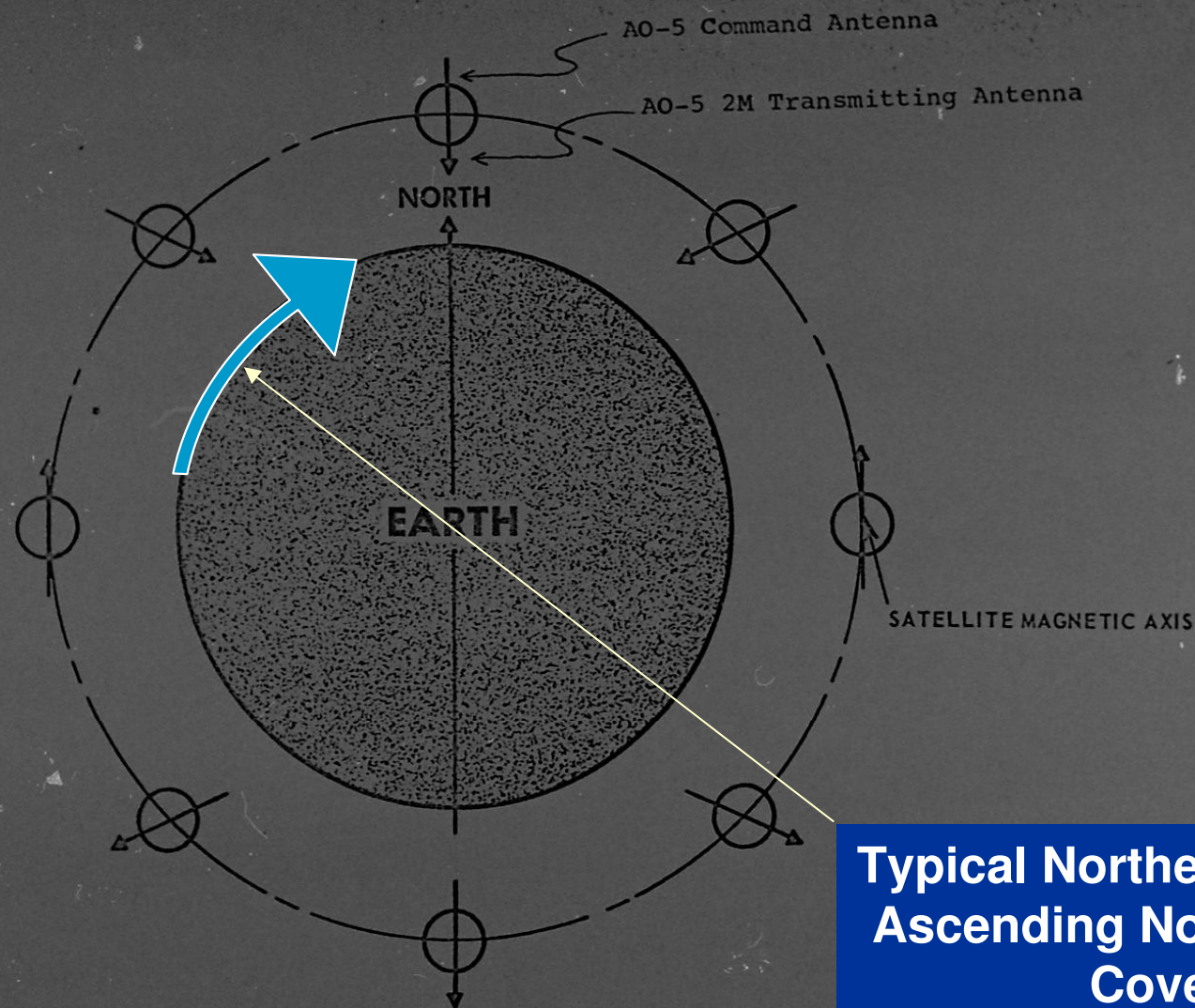


Fig. 5 MOTION OF A MAGNETICALLY ORIENTED SATELLITE IN A POLAR ORBIT

PMASS Performance and the Attitude Sensors

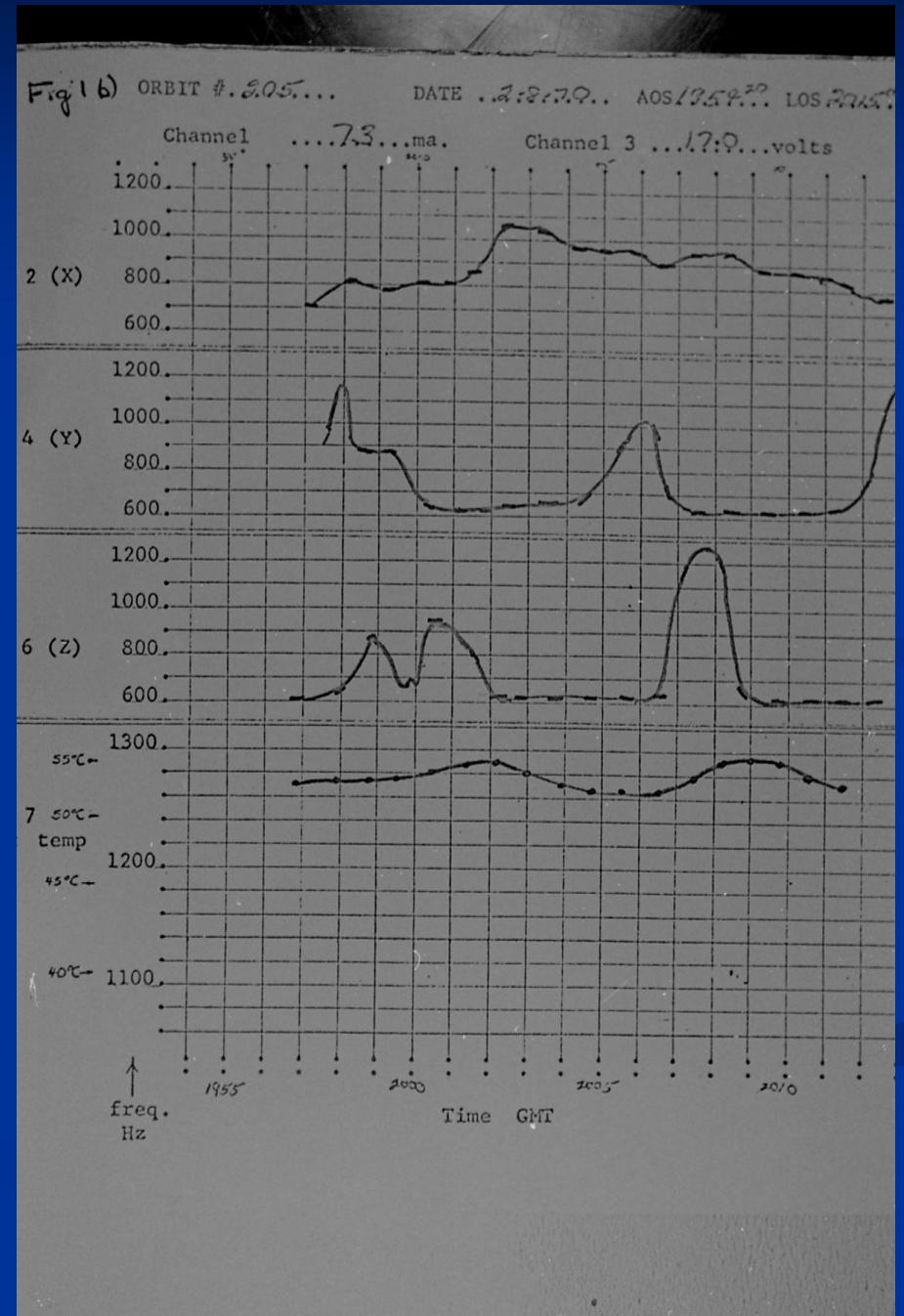
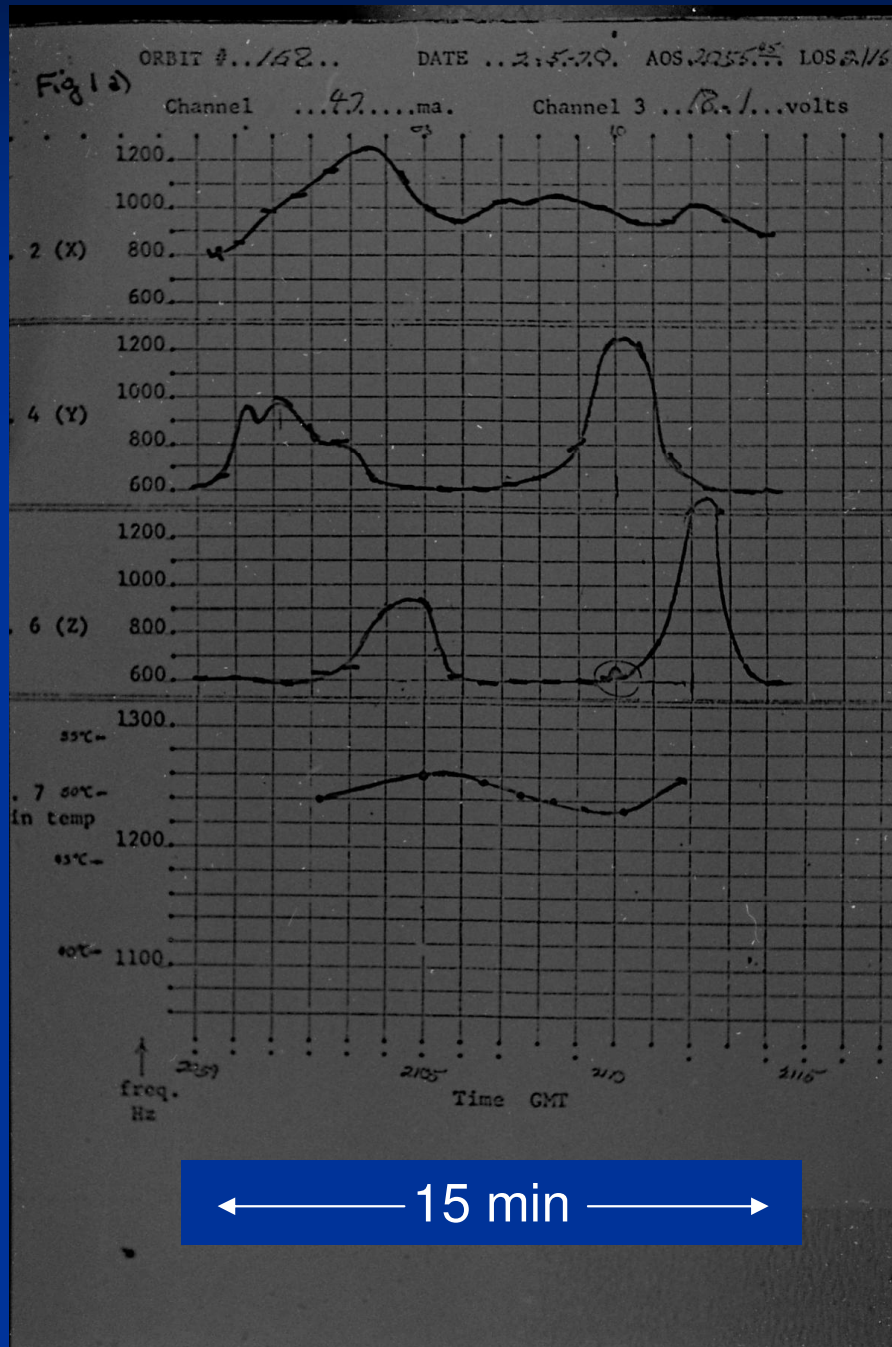
- Data From an Entire Pass -

X

Y

Z

T



PMASS Performance and the Attitude Sensors (2)

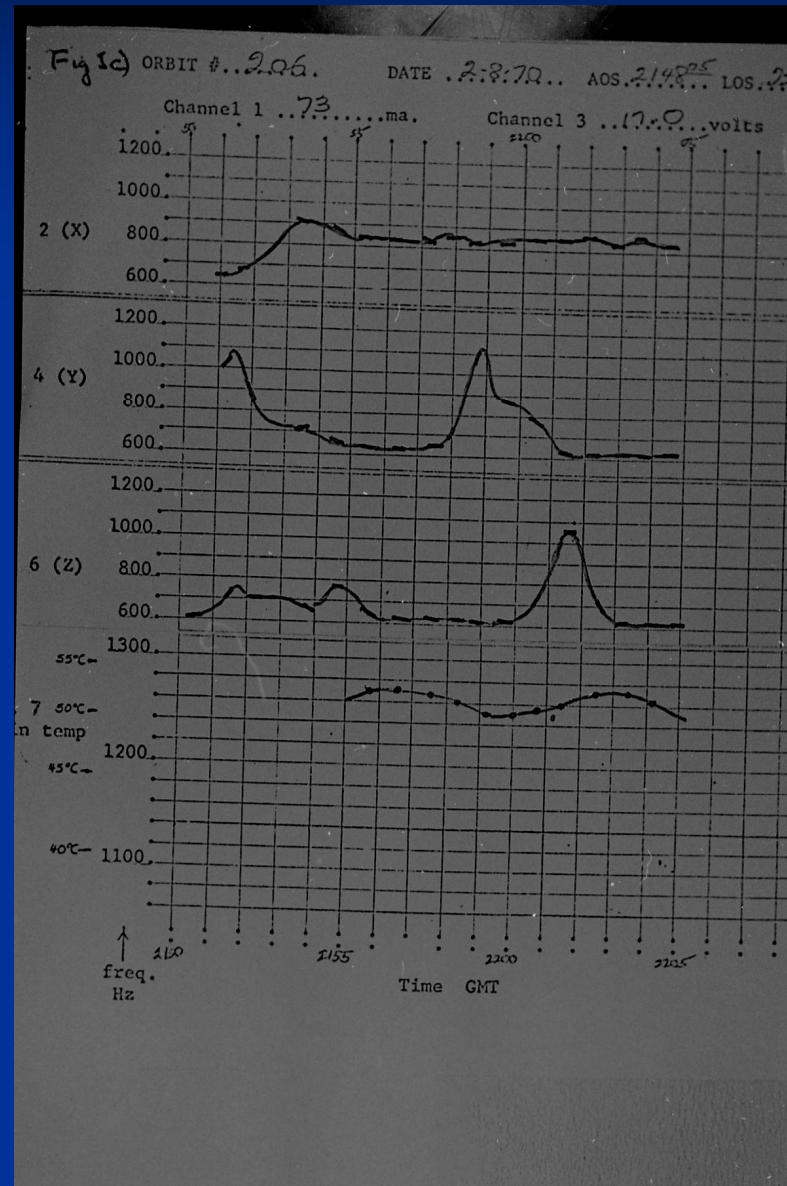
- Data From an Entire Pass -

X

Y

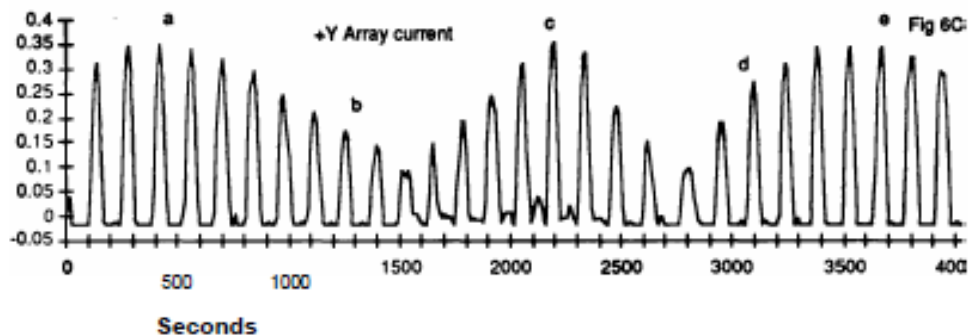
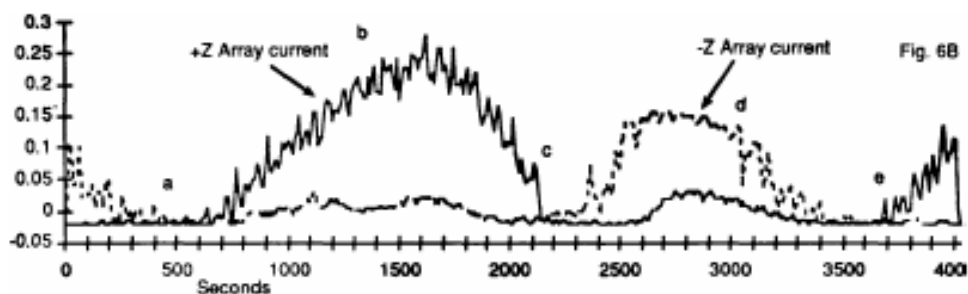
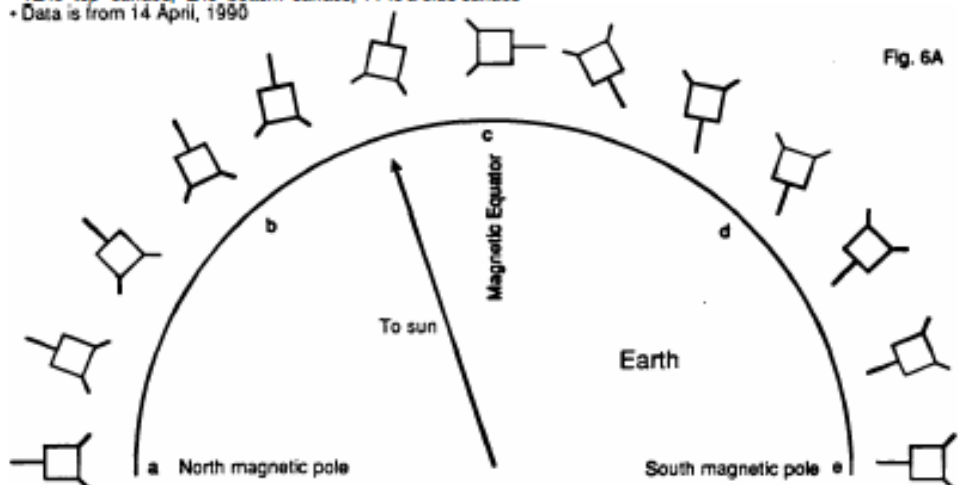
Z

T



AMSAT-NA MICROSAT STABILIZATION AND ARRAY CURRENT EXAMPLES

- Array current plots are sun-lit portion of orbit, s/c chart is one half orbit
- Angles are to scale in Fig. 6a
- Letters a - e refer to same points in orbit on the three charts
- +Z is "top" surface, -Z is "bottom" surface, +Y is a side surface
- Data is from 14 April, 1990



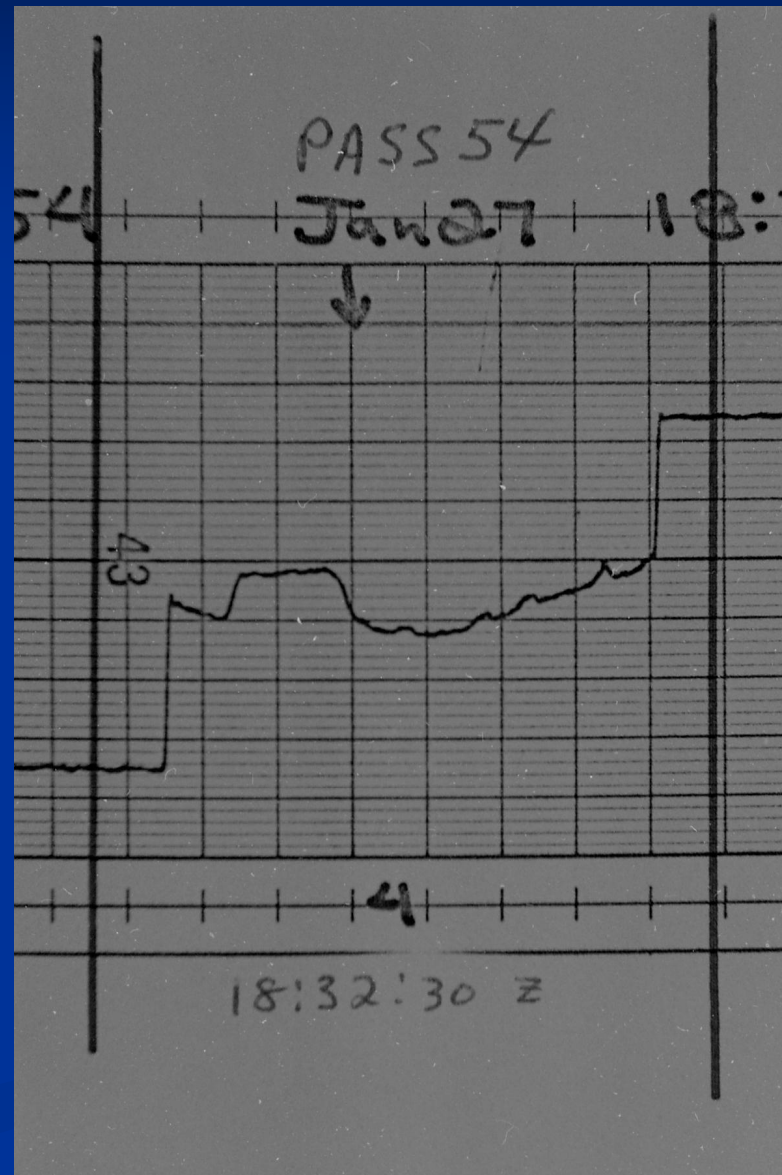
**PMASS Systems
Are Still Used
Today, Even by
Professional
Small Satellites.
Here is
Whole Orbit Data
From AO-16
taken in 1990.
AO-5 Really
Started
Something.**

This is solar array data, not horizon sensor data.

PMASS Performance and the Attitude Sensors (3)

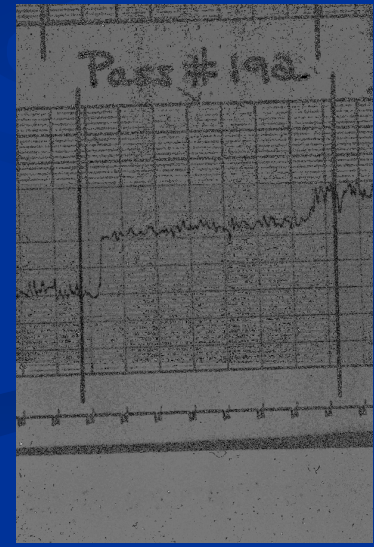
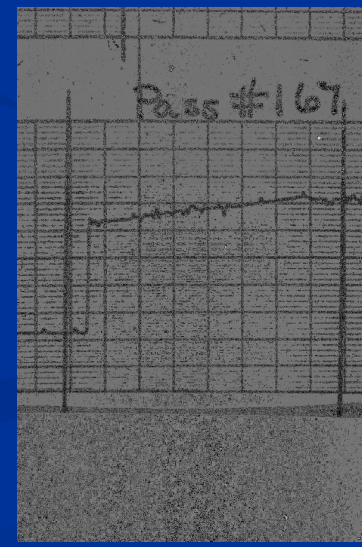
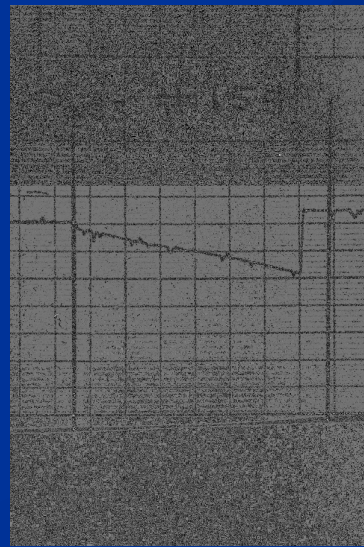
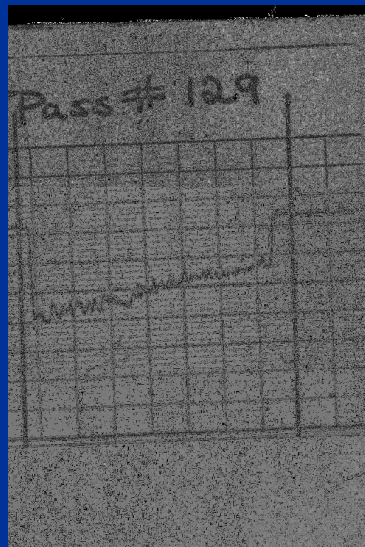
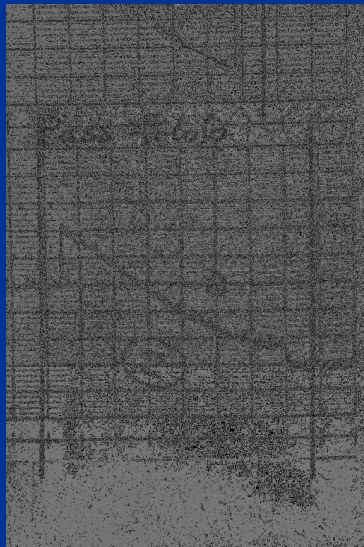
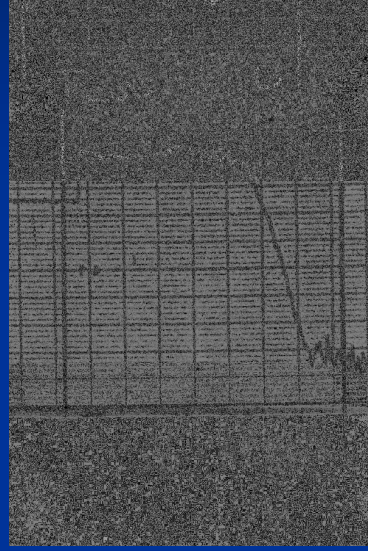
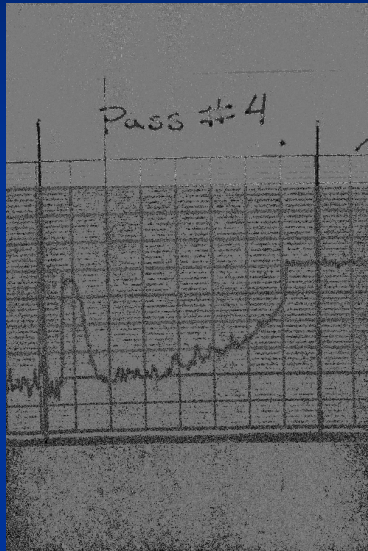
- Individual Sample (Freq. $\rightarrow$ Voltage) Measurements -

Increasing Light Intensity $\uparrow$



PMASS Performance and the Attitude Sensors (4)

- Individual Sample (Freq. $\rightarrow$ Voltage) Measurements -
- The Spin Down of the Spacecraft -



What We Learned from AO-5 PMASS and From Subsequent Missions Using the Same Technology

- If the permanent magnet dipole moment is as strong as the one used in AO-5, and if the spacecraft release from the launcher is nominal, the satellite will “lock” to the Earth’s magnetic field within a few days.
- The hysteresis rods will quickly damp out nutations around the magnetic, however, precessions still will exist, depending on the mass properties of the satellite.
- Due to residual magnetic effects (hysteresis, stray fields, eddy currents) the satellite will always spin down to zero rate over time.
- It may be helpful to introduce a rate about the magnetically stabilized axis. This may be done passively using a “photon propeller” as was used on the AO-7 mission.

29 MHz Beacon Experiment Results

TABLE I

Pass Duration
(from acquisition of signal to loss of signal)
29 MHz vs. 144 MHz.

	<i>29 MHz Longer than 144 MHz</i>	<i>144 MHz Longer than 29 MHz</i>
Total Simultaneous Reports Showing Differences	177 (68%)	83 (32%)
Daytime Only	118 (68%)	58 (32%)
Nighttime Only	59 (70%)	25 (30%)
Majority of Reports at Each Station (By Stations)	23 (70%)	10 (30%)

29 MHz Beacon Antipodal Propagation Reports – Real Physics Too!

TABLE II
Reports of Antipodal Propagation

Orbit	Station	Date	Hour GMT	RS	Notes
	VK8KK	1/23	13		(S)
2	WØZWW	1/23	16		(S) Weak, Fluttery
12	K2SS	1/23	11 34		
28	K2SS	1/25	18 33		
29	K2SS	1/25	19-20		(S) Continuous reception for 68 min.
31	WA4JID	1/25	23 42		(S) Beam 180 degrees
32	WA7DUR/7	1/26	01		(S)
41	K2SS	1/26	19 44		(S)
87	K2SS	1/30	22		
90	K1HTV	1/30	17 23		(S)
105	K2QBW	1/31	21 14		(S)
181	WA4JID	2/6	19 41		(S)
192	W9BHR	2/7	20		(S) Beam SSE
201	F2DC	2/8	13		(S)
203	K2SS	2/8	17		(S)
279	K2SS	2/14	19 56		(S)
279	K3JTE	2/14	19		(S) Five minutes later than K2SS
280	K2SS	2/14	21 33		(S)
292	K2SS	2/15	20 45		(S) HI-keyer possibly heard
304	K2SS	2/16	19 53		
367	K2SS	2/21	20 53		(S)
378	K2SS	2/22	17 42		(S)
379	K2SS	2/22	19 43		(S)
380	K2SS	2/22	21 22		(S)
381	K2SS	2/22	23		(S)
404	K2SS	2/24	19 32		(S)
405	K2SS	2/24	21 21		(S)
453	K2SS	2/28	17 22		(S)
454	K2SS	2/28	19 55		(S)
466	K2SS	3/1	18 32		
467	K2SS	3/1	20 52		
468	K2SS	3/1	22 52		(S)
542	ZZ1HC*	3/7	18 17		(S)
543	WA4JID	3/7	21 53		(S) Beam 180 degrees
543	K3JTE	3/7	21 46		(S) Simultaneously with WA4JID but longer duration

Notes: (S) denotes orbit number during which other skip was reported in addition to antipodal. *ZZ1HC is Mr. H. Cooperman of Winnipeg, Manitoba. Mean and median normalized signal strength: S3.

To correct for variations in signal strength judgments, the values in the RS column have been normalized based upon the strongest line-of-sight report from each station being placed equal to S9.

Totals: 35 reports from 11 stations. 27 of 33 orbits reported above, or 82%, were denoted by (S).